

CLAIMS

Therefore, the following is claimed:

- 1 1. A micro electro-mechanical device packaging system, comprising:
2 a micro electro-mechanical device formed on a substrate layer; and
3 a protective structure protecting at least a portion of the micro electro-
4 mechanical device, wherein the protective structure is formed on the substrate layer
5 and surrounds a gas cavity enclosing an active surface of the micro electro-mechanical
6 device, the protective structure being a solid.
- 1 2. The system of claim 1, wherein the substrate layer comprises silicon
2 material.
- 1 3. The system of claim 1, wherein the substrate layer comprises non-
2 silicon material.
- 1 4. The system of claim 1, wherein the protective structure comprises a
2 metal material.
- 1 5. The system of claim 4, wherein the metal material is deposited by
2 sputtering.
- 1 6. The system of claim 1, wherein the protective structure comprises an
2 overcoat polymer material.
- 1 7. The system of claim 6, wherein the overcoat polymer material is
2 deposited by spin-coating.
- 1 8. The system of claim 6, further comprising:
2 an additional protective structure surrounding the overcoat polymer material.

1 9. The system of claim 8, wherein the additional protective structure
2 comprises a metal material.

1 10. The system of claim 1, wherein the protective structure comprises a
2 modular polymer that includes the characteristic of being permeable to the
3 decomposition gases produced by the decomposition of a sacrificial polymer while
4 forming the gas cavity.

1 11. The system of claim 1, wherein the gas cavity is substantially free of
2 residue.

1 12. The system of claim 11, wherein the gas cavity is vacuum-packed.

1 13. The system of claim 1, wherein protective structure has not been
2 preformed before being applied to the substrate layer.

1 14. The system of claim 13, further comprising:
2 a metal packaging frame, the micro electro-mechanical device being attached
3 to the metal packaging frame; and
4 a coating material encapsulating a portion of the micro electro-mechanical
5 device and metal packaging frame assembly.

1 15. A micro electro-mechanical device packaging system, comprising:
2 a micro electro-mechanical device formed on a substrate layer; and
3 a thermally decomposable sacrificial structure protecting at least a portion of
4 the micro electro-mechanical device, wherein the sacrificial structure is formed into
5 a gas cavity enclosing an active surface of the micro electro-mechanical device.

1 16. The system of claim 15, wherein the sacrificial structure comprises a
2 photo-definable polycarbonate material.

1 17. The system of claim 15, wherein the sacrificial structure is deposited
2 by spin-coating followed by patterning.

1 18. The system of claim 17, wherein the sacrificial structure comprises a
2 photo-definable material.

1 19. The system of claim 15, wherein the sacrificial structure is dispensed
2 by a syringe dispensing tool.

1 20. The system of claim 19, wherein the sacrificial structure comprises a
2 non-photo-definable material.

1 21. The system of claim 15, further comprising:
2 a metal packaging frame, the micro electro-mechanical device being attached
3 to the metal packaging frame; and
4 a coating material encapsulating a portion of the micro electro-mechanical
5 device and metal packaging frame assembly, the coating material including the
6 characteristic of being permeable to the decomposition gases produced by the
7 decomposition of a sacrificial polymer at a temperature exceeding a curing
8 temperature of the coating material.

1 22. The system of claim 21, wherein the coating material comprises an
2 epoxy resin.

1 23. The system of claim 21, further comprising:
2 an overcoat structure surrounding the sacrificial structure, the overcoat
3 structure comprising a modular polymer that includes the characteristic of being
4 permeable to the decomposition gases produced by the decomposition of a sacrificial
5 polymer from inside the gas cavity.

1 24. A method for producing a micro electro-mechanical device package,
2 comprising the steps of:

3 forming a thermally decomposable sacrificial layer on a substrate of a micro
4 electro-mechanical device, the sacrificial layer encapsulating a portion of the micro
5 electro-mechanical device;

6 forming a protective layer around the sacrificial layer; and

7 thermally decomposing the sacrificial layer, wherein decomposed molecules of
8 the sacrificial layer permeate through the protective layer, and wherein a gas cavity is
9 formed where the thermally decomposable sacrificial layer was formed.

1 25. The method of claim 24, further comprising the steps of:

2 depositing the sacrificial layer by spin-coating; and

3 patterning the sacrificial layer.

1 26. The method of claim 24, wherein the sacrificial layer has a

2 decomposition temperature less than a decomposition temperature of the substrate and
3 a decomposition temperature of the protective layer.

1 27. The method of claim 24, wherein the substrate comprises a silicon

2 material.

1 28. The method of claim 24, wherein the substrate comprises a non-silicon

2 material.

1 29. The method of claim 24, wherein the thickness of the protective layer

2 is within the range of 50 nm and 500 μ m.

1 30. The method of claim 24, wherein the protective layer has not been

2 perforated.

1 31. The method of claim 24, wherein the protective layer is substantially

2 free of sacrificial material after the sacrificial material has been thermally
3 decomposed.

1 32. The method of claim 24, wherein the protective layer provides an
2 airtight enclosure around the gas cavity.

1 33. The method of claim 32, wherein the protective layer provides
2 protection from mechanical forces.

1 34. The method of claim 33, wherein the protective layer further provides
2 protection against water.

1 35. The method of claim 34, wherein the protective layer further provides
2 protection against oxygen gas.

1 36. The method of claim 34, wherein the protective layer further provides
2 protection against exposure to gaseous materials.

1 37. The method of claim 24, wherein the micro electro-mechanical device
2 includes a released mechanical structure before the sacrificial material is formed.

1 38. The method of claim 24, further comprising the steps of:
2 before the protective layer is formed, attaching the micro electro-mechanical
3 device to a metal packaging frame, wherein the protective layer comprises an epoxy
4 resin encapsulating the micro electro-mechanical device and metal packaging frame
5 assembly.

1 39. The method of claim 38, further comprising the step of:
2 heating the micro assembly at a temperature for curing the protective layer;
3 and
4 heating the micro assembly at a temperature for decomposing the sacrificial
5 layer, the temperature for decomposing the sacrificial layer exceeding the temperature
6 for curing the protective layer.

1 40. The method of claim 24, further comprising the step of:
2 forming a barrier layer around the protective layer, the barrier layer providing a
3 stronger protection against mechanical forces than the protective layer.

1 41. The method of claim 40, wherein the barrier layer comprises a metal
2 material.

1 42. The method of claim 40, further comprising the steps of:
2 creating a vacuum inside the gas cavity by heating the micro electro-
3 mechanical device in a chamber; and
4 after the vacuum is created, forming a barrier layer around the protective layer
5 within the chamber to provide a vacuum-packed enclosure around the gas cavity, the
6 barrier layer comprising a metal material.

1 43. The method of claim 42, further comprising the steps of:
2 after the barrier layer is formed, attaching the micro electro-mechanical device
3 to an integrated circuit package structure; and
4 encapsulating the electro-mechanical device and integrated circuit package
5 structure in a protective coating.

1 44. The method of claim 42, wherein the integrated circuit package
2 structure comprises a leadframe.

1 45. The method of claim 42, wherein the integrated circuit package
2 structure comprises a ceramic package.

1 46. The method of claim 42, wherein the step of thermally decomposing
2 the sacrificial layer occurs inside the vacuum chamber.

1 47. The method of claim 24, further comprising the steps of:
2 after the sacrificial layer is decomposed, attaching the micro electro-
3 mechanical device to an integrated circuit package structure; and
4 encapsulating the electro-mechanical device and package structure in a
5 protective coating.

1 48. The method of claim 47, wherein the integrated circuit package
2 structure comprises a leadframe.

1 49. The method of claim 47, wherein the integrated circuit package
2 structure comprises a ceramic package.

1 50. The method of claim 24, wherein thermal decomposition temperature
2 of the sacrificial material is less than 100 degrees Celsius.